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ABSTRACT

Simulation studies of the performance of (potentially) robust statistical estimation produce large quantities of numbers in the form of performance indices of the various estimators under various conditions. This report presents a multivariate graphical display used to aid in the digestion of the plentiful results in a current study of Item Response Theory (IRT) ability estimators. Called XTREE, or the "Christmas Tree Glyph," the display has a vertical line or "trunk" with angled lines or "branches" for each estimator which display bias (left) and random variance (right). The sum of the two branch lengths represents the mean square error (MSE). Appendix A is a tabular presentation of the results to illustrate the data interpretation problem. Appendix B contains the XTREE computer programs (written in FORTRAN IV for a Honeywell DPS computer system and a Hewlett-Packard 7470A plotter). (Author/BS)

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The Graphical Display of Simulation Results, with Applications
to the Comparison of Robust IRT Estimators of Ability

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Abstract

Simulation studies of the performance of (potentially) robust statistical estimators usually proceed by applying each of several estimators to several samples of datasets generated under a variety of circumstances. The estimators which do "best" (have the least bias or MSE or both) under many circumstances are declared "good". Such studies produce large quantities of numbers, in the form of indices of the performance of the various estimators under various conditions. These numbers form the results of the study, and so must be examined in detail. In our current study of robust IRT ability estimators, tabular presentation of the results has become truly unmanageable; that is, obtaining the numbers or doing the simulation is only part of the problem, understanding the excessively plentiful results is another considerable part. To aid in the digestion of such a collection of numbers, we have turned to multivariate graphical display.

The Graphical Display of Simulation Results,
with Applications to the Comparison of
Robust IRT Estimators of Ability

Simulation studies of the performance of (potentially) robust statistical estimators usually proceed by applying each of several estimators to several samples of datasets generated under a variety of circumstances. The estimators which "do best" (have the least bias or MSE or both) under many circumstances are declared "good." The prototypical example of the genre is the "Princeton Robustness Study" (Andrews, Bickel, Hampel, Huber, Rogers, and Tukey, 1972) of estimators of location. Our current study (Wainer and Thissen, 1984) of robust IRT ability estimators is another example of the form.

Such studies produce large quantities of numbers, in the form of indices of the performance of the various estimators under various conditions. These numbers frequently include bias (or squared bias), error variance, and MSE. These form the results of the study, and so must be examined in detail. The numbers may be presented in tabular form, as in the Andrews et al. (1972) monograph, but sheer quantity makes this form of presentation difficult.

In our current study of robust IRT ability estimators, tabular presentation of the results has become truly unmanageable. The table in Appendix A illustrates the problem. Appendix A includes tabular presentation of the results of our investigation of 28 IRT estimators of ability (nine estimators: MEAN, M.25, M.50, M1.0, MODE, H0.5, H1.0, H2.0, and BIWT with each of three models: 1-PL, 2-PL, and 3-PL, as well

Robust Estimation of Ability

Graphical Display - 2

as AMJK under the 1-PL model only) for a single set of four items. [See Wainer and Thissen (1984) for definitions of the codes used here for estimators, models and scaling conventions (in the following).] Each of the 28 estimators was examined at five levels of ability (-2, -1, 0, +1, and +2). Three possible scaling conventions are considered: the "natural" scaling of each estimator as it stands, a rescaling which matches the variance of the test sample (VARM) and rescaling to minimize MSE in the test sample. Thus, there are 28 (estimator/model combinations) $\times$ 5 (ability levels) $\times$ 3 (scaling conventions) = 420 entries in the table.

Each entry is multivariate. The mean is given (UBAR), followed by bias (DBAR = true value - UBAR), the standard deviation of the estimates, and RMSE = $\text{SQRT}(\text{bias}^2 + \text{SD}^2)$. Strictly speaking, the data are bivariate, since UBAR and RMSE are dependent on DBAR and SD, but each of these forms is sometimes conceptually useful. Thus, Appendix A contains $420 \times 4 = 1680$ numbers.

So obtaining the numbers, or doing the simulation, is only part of the problem. Understanding the excessively plentiful results is another considerable part of the problem. The results are not terribly clear in Appendix A. To aid in the digestion of such a collection of numbers, we have turned to multivariate graphical display. The core of the display is XTREE, the "Christmas Tree Glyph." Computer programs for producing XTREES are documented and reproduced in Appendix B; interpretation of the XTREE graphical device follows.

The XTREE glyph is a specialized graphical device developed for the display of the outcome of simulation studies of statistical

estimators, modeled loosely on the "metr glyph" proposed by Anderson (1960). XTREES are so-called because of their similarity to Christmas trees for some datasets. Display 1 is the "key" for interpreting the XTREES used to compare estimators within a model (1-PL, 2-PL, or 3-PL) for a particular ability level.

The example in Display 1 will be used to describe the features of the XTREE plots. In keeping with the XTREE metaphor, the vertical line will be called the "trunk" and the angled lines the "branches." In all XTREES, the branches on the left display bias² and the branches on the right display random variance. The lowest branches provide a numerical standard for the icon: the lengths of those branches are to be given in the caption, and provide for approximate numerical interpretation (by eye) of the other branches. Frequently, the standard branch on the bias² (left) side is 4 ($=2^2$, where 2 is the maximum bias readily obtained in this study) and the standard for the random variance (right) side is 1, the maximum random variance obtainable here. These values are adjusted as circumstances require to produce useful displays.

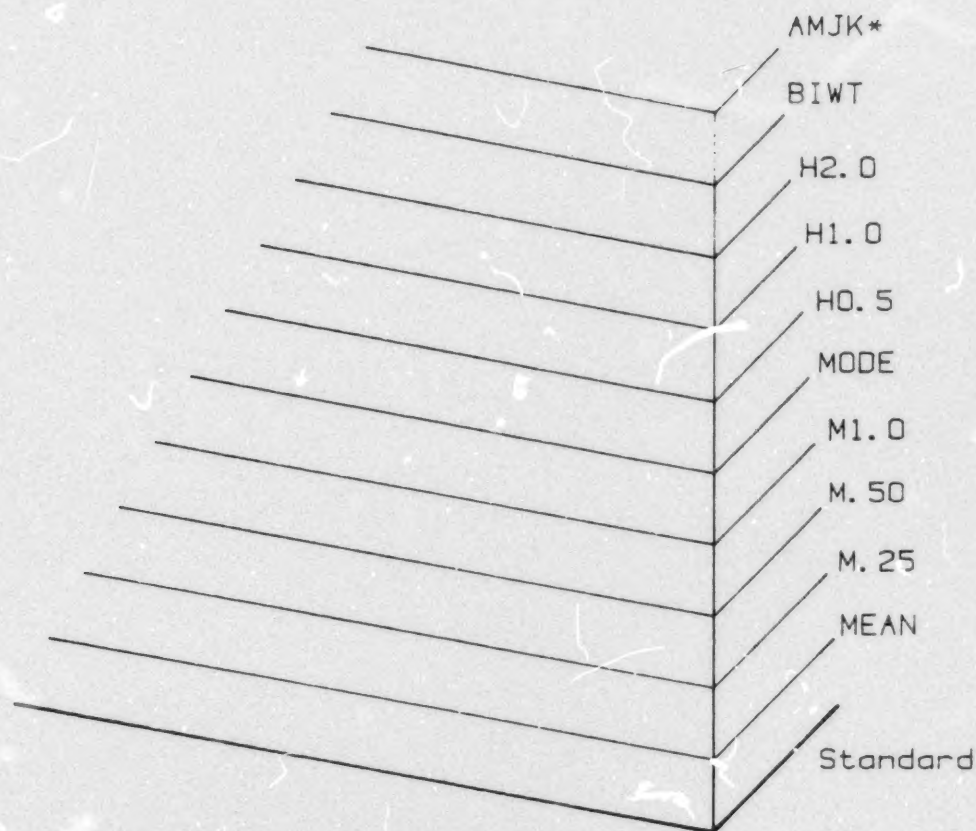
Each estimator is allocated a pair of branches (a left and a right from the same node) in Display 1; the branches are identified on the right. In the actual data analytic versions, with many small XTREES on a page, the estimator names are omitted. The key is to be used to identify estimators with branches, as the estimators are always assigned to the same branches, in order, bottom-to-top.

The length of an estimator's left branch represents that estimator's bias², relative to the standard or the other estimators. The length of each estimator's right branch represents its random variance

Robust Estimation of Ability

Graphical Display - 4

Key for the ten- (or so) branch glyphs



Each glyph is within a model at an ability level

Only one scaling is shown; it is identified

upper left: RMSE is "as is," REVM is
variance-matching, and REMI is MIN(RMSE)

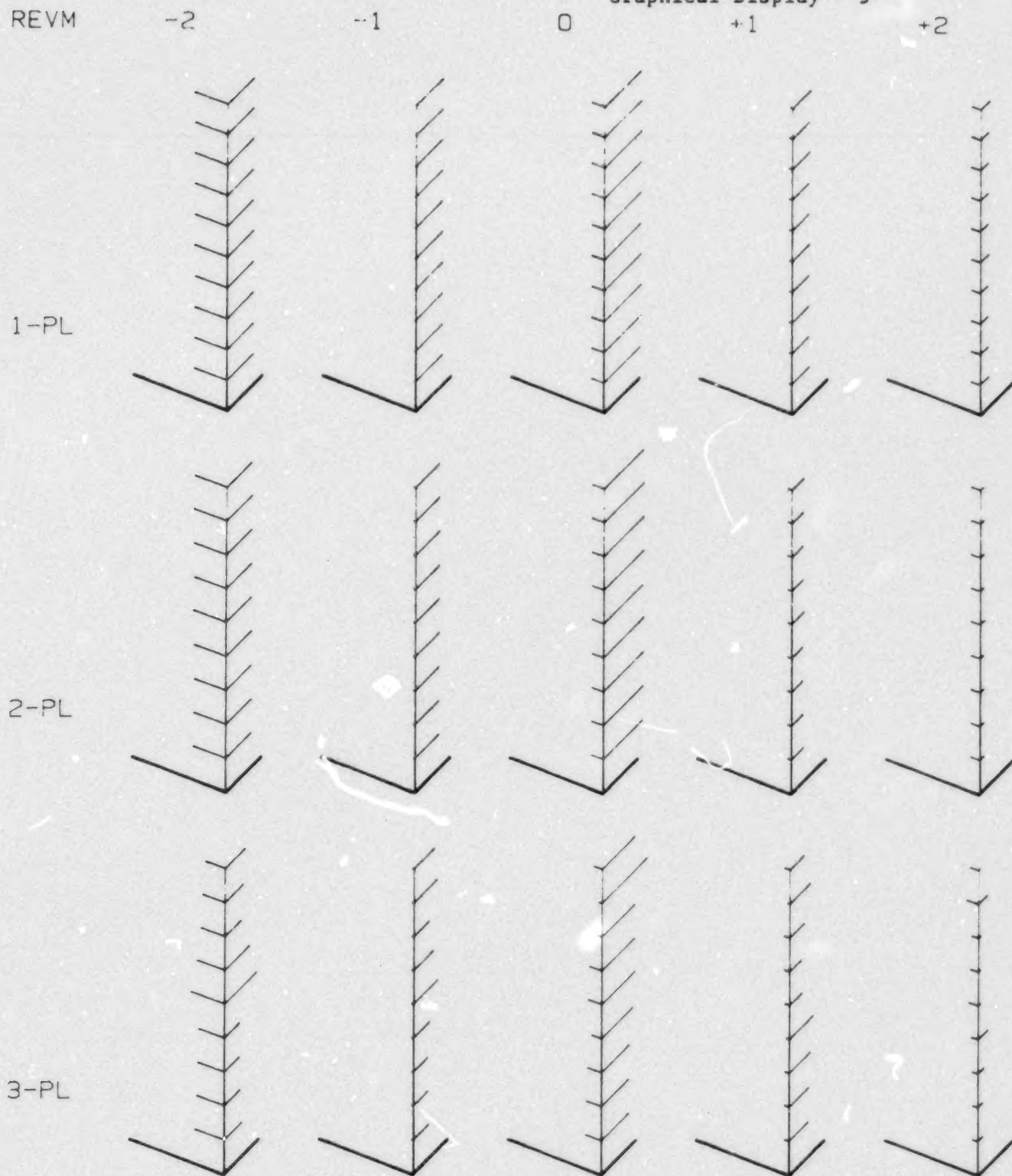
There is a branch for each estimator

*AMJK only for 1-PL

BIAS**2 is on

the left, and random variance is on the right

Display 1



4-item WK simulation
2:1 bias**2:random**2 bases

Display 2

Robust Estimation of Ability

Graphical Display - 6

similarly. The sum of the two lengths (or breadth of the tree at that point) represents MSE for that estimator. Thus, short branches are good and longer ones are bad.

Display 2 illustrates the results, with variance-matching scaling, for all the estimators (in the XTREES) and all models (1-PL, 2-PL, and 3-PL; row labels) at all five ability levels (column labels) for the four-item results in Appendix A. Thus, one third of the numbers in Appendix A are in Display 2. The bases (standard branches) are equal to 2.0 on the left and 1.0 on the right. The numbers used are in the VARM sections of Appendix A. For example, the lowest branches (above the standard) for the upper left-hand XTREE (1-PL, ability = -2) are $(-0.83)^2$ and 0.85^2 in length.

Display 2 shows patterns not readily obvious in Appendix A:

- The performance of the estimators varies markedly (and consistently) among the five levels of ability.
- Within levels of ability, differences are much smaller; but the 3-PL estimators generally do better than the 2-PL estimators, which do better than the 1-PL versions.
- 3-PL MODE (middle branches, bottom left XTREE) is surprisingly bad; those atypically long branches represent bias = -0.84 and SD = 0.94, both of which are worse than the 1-PL MEAN numbers given above.

Visual salience of such results is the reason for the development of the XTREE displays.

It is also useful to compare the outcomes under different scaling conventions. Display 3 illustrates the "key" for the interpretation of XTREES in which the three branches correspond to the three scalings

("natural," variance matching, and $\text{MIN}[\text{MSE}]$) for each estimator at each level of ability. Display 4 shows the WK-4 outcome for the 3-PL estimators under all three scalings. Again, one third of the numbers in Appendix A are in Display 4.

The XTREE Programs

The computer programs used to produce the XTREE displays are reproduced in Appendix B. Displays 1 and 3 were produced by EXPLTREE, a program to make explanatory XTREEs, and Display 4 was made by TREE1 and Display 2 by TREE3. All programs are written in FORTRAN IV for a Honeywell DPS computer system, and produce output to drive a Hewlett-Packard 7470A plotter.

Robust Estimation of Ability

Graphical Display - 8

Top branch is for MIN(RMSE) scaling

This branch is for scaling to match
variance

This branch is for "natural" scaling

The bottom branches are "standards"
usually 4 on the left 1 on the right

This is the "key" for the "four-branch" tree-glyphs
There is one glyph for each estimator within each
model at each level of ability
Bias**2 is on the left side of the tree
(usually, but not always, between 0 and 4)
Random variance is on the right
(usually 0-1)
Total MSE is obtained as the sum of the lengths

Display 3

4-item WK simulation

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3-PL

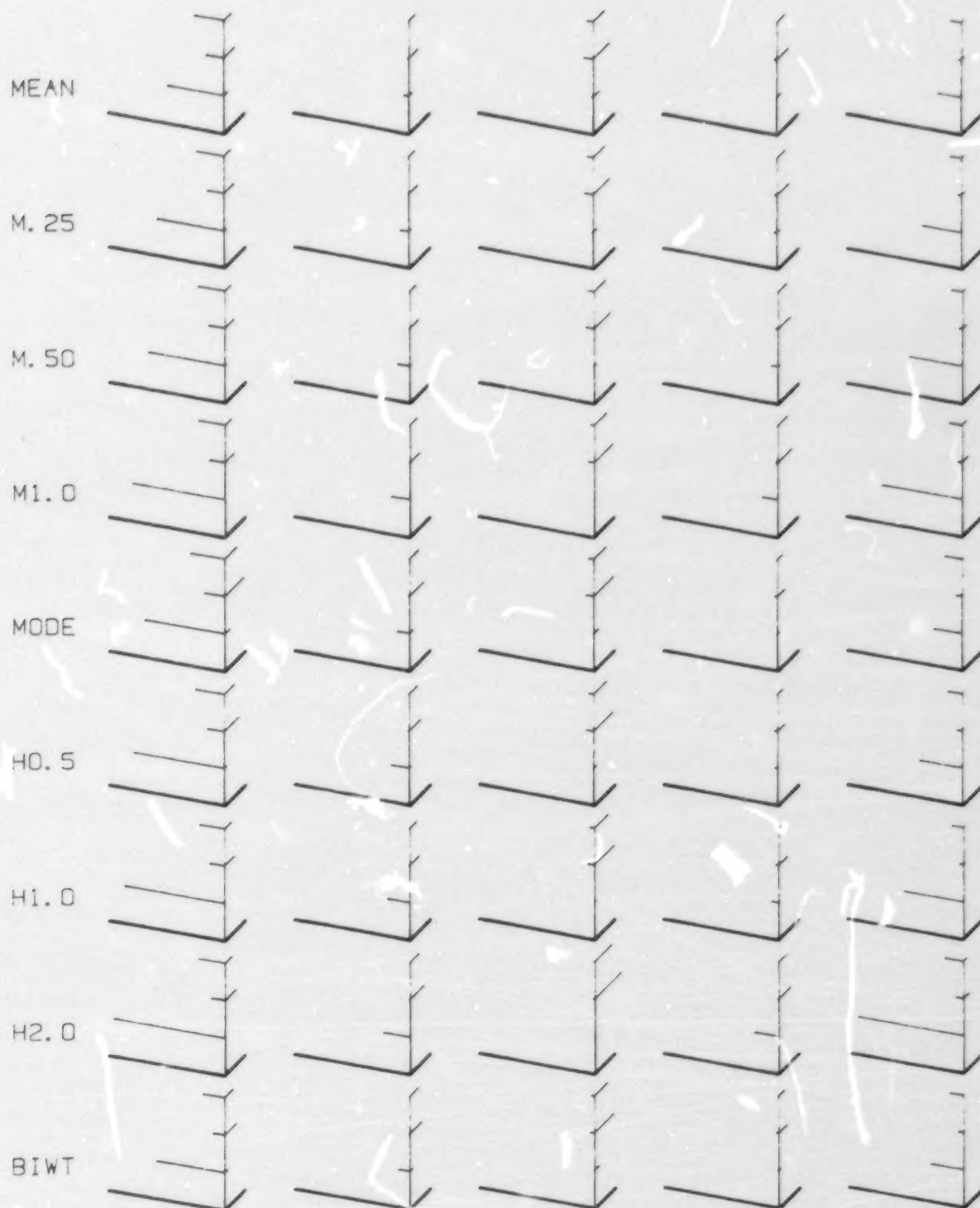
-2

-1

0

+1

+2



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Technometrics, 1960, 2, 387-391

Andrews, D.F., Bickel, P.J., Hampel, F.R., Huber, P.J., Rogers, W.H.,

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Ms. in preparation, 1984.

Appendix A: 4-Item WK Simulation Outcome

		-2	-1	0	+1	+2
1-PL	UBAR	-0.59	-0.55	-0.22	0.75	0.94
MEAN	DBAR	-1.41	-0.45	0.22	0.25	1.06
	S.D.	0.48	0.48	0.57	0.39	0.27
	RMSE	1.49	0.66	0.61	0.46	1.10
VARM	UBAR	-1.17	-1.10	-0.51	1.23	1.56
	DBVM	-0.83	0.10	0.51	-0.23	0.44
	SDVM	0.86	0.87	1.01	0.70	0.48
	REVM	1.20	0.87	1.14	0.73	0.65
MINV	UBAR	-0.91	-0.86	-0.40	0.95	1.21
	DBMI	-1.09	-0.14	0.40	0.05	0.79
	SDMI	0.67	0.67	0.79	0.54	0.37
	REMI	1.28	0.69	0.88	0.54	0.87
1-PL	UBAR	-0.47	-0.44	-0.18	0.60	0.74
M.25	DBAR	-1.53	-0.56	0.18	0.40	1.26
	S.D.	0.38	0.38	0.45	0.30	0.21
	RMSE	1.57	0.68	0.49	0.50	1.27
VARM	UBAR	-1.17	-1.10	-0.51	1.23	1.56
	DBVM	-0.83	0.10	0.51	-0.23	0.44
	SDVM	0.86	0.86	1.02	0.68	0.47
	REVM	1.19	0.87	1.14	0.72	0.64
MINV	UBAR	-0.92	-0.86	-0.40	0.96	1.21
	DBMI	-1.08	-0.14	0.40	0.04	0.79
	SDMI	0.67	0.67	0.79	0.53	0.36
	REMI	1.27	0.69	0.89	0.53	0.87
1-PL	UBAR	-0.37	-0.35	-0.14	0.47	0.58
M.50	DBAR	-1.63	-0.65	0.14	0.53	1.42
	S.D.	0.30	0.30	0.36	0.24	0.16
	RMSE	1.65	0.72	0.38	0.58	1.42
VARM	UBAR	-1.18	-1.11	-0.51	1.24	1.56
	DBVM	-0.82	0.11	0.51	-0.24	0.44
	SDVM	0.86	0.86	1.02	0.68	0.46
	REVM	1.19	0.87	1.14	0.72	0.64
MINV	UBAR	-0.92	-0.86	-0.40	0.97	1.21
	DBMI	-1.08	-0.14	0.40	0.03	0.79
	SDMI	0.67	0.67	0.80	0.53	0.36
	REMI	1.27	0.69	0.89	0.53	0.86
1-PL	UBAR	-0.22	-0.21	-0.08	0.28	0.35
M1.0	DBAR	-1.78	-0.79	0.08	0.72	1.65
	S.D.	0.18	0.18	0.21	0.14	0.09
	RMSE	1.79	0.81	0.23	0.73	1.66
VARM	UBAR	-1.17	-1.11	-0.51	1.24	1.56
	DBVM	-0.83	0.11	0.51	-0.24	0.44
	SDVM	0.85	0.86	1.02	0.68	0.46
	REVM	1.19	0.87	1.14	0.72	0.64
MINV	UBAR	-0.92	-0.86	-0.40	0.96	1.22
	DBMI	-1.08	-0.14	0.40	0.04	0.78
	SDMI	0.67	0.67	0.79	0.53	0.36
	REMI	1.27	0.69	0.89	0.53	0.86

Graphical Display - A-2
4-item WK simulation, numbers used in trees

	-2	-1	0	+1	+2
1-PL UBAR	-0.56	-0.52	-0.21	0.71	0.89
MODE DBAR	-1.44	-0.48	0.21	0.29	1.11
S.D.	0.46	0.46	0.54	0.37	0.26
RMSE	1.51	0.66	0.58	0.47	1.14
VARM UBAR	-1.17	-1.10	-0.51	1.22	1.56
DBVM	-0.83	0.10	0.51	-0.22	0.44
SDVM	0.86	0.87	1.01	0.70	0.48
REVM	1.20	0.87	1.14	0.73	0.66
MINV UBAR	-0.91	-0.85	-0.40	0.95	1.21
DBMI	-1.09	-0.15	0.40	0.05	0.79
SDMI	0.67	0.67	0.79	0.54	0.38
REMI	1.28	0.69	0.88	0.54	0.87
1-PL UBAR	-0.36	-0.34	-0.14	0.45	0.56
H0.5 DBAR	-1.64	-0.66	0.14	0.55	1.44
S.D.	0.29	0.29	0.34	0.23	0.15
RMSE	1.67	0.72	0.37	0.59	1.45
VARM UBAR	-1.18	-1.11	-0.51	1.24	1.56
DBVM	-0.82	0.11	0.51	-0.24	0.44
SDVM	0.85	0.86	1.02	0.68	0.46
REVM	1.19	0.87	1.14	0.72	0.64
MINV UBAR	-0.92	-0.86	-0.40	0.97	1.22
DBMI	-1.08	-0.14	0.40	0.03	0.78
SDMI	0.67	0.67	0.80	0.53	0.36
REMI	1.27	0.69	0.89	0.53	0.86
1-PL UBAR	-0.22	-0.20	-0.08	0.27	0.34
H1.0 DBAR	-1.78	-0.80	0.08	0.73	1.66
S.D.	0.17	0.17	0.21	0.14	0.09
RMSE	1.79	0.82	0.22	0.74	1.67
VARM UBAR	-1.17	-1.10	-0.52	1.24	1.56
DBVM	-0.83	0.10	0.52	-0.24	0.44
SDVM	0.86	0.86	1.02	0.68	0.46
REVM	1.19	0.87	1.14	0.72	0.64
MINV UBAR	-0.92	-0.86	-0.40	0.96	1.22
DBMI	-1.08	-0.14	0.40	0.04	0.78
SDMI	0.67	0.67	0.80	0.53	0.36
REMI	1.27	0.69	0.89	0.53	0.86
1-PL UBAR	-0.06	-0.06	-0.02	0.08	0.10
H2.0 DBAR	-1.94	-0.94	0.02	0.92	1.90
S.D.	0.05	0.05	0.06	0.04	0.03
RMSE	1.94	0.94	0.07	0.92	1.90
VARM UBAR	-1.17	-1.10	-0.52	1.24	1.55
DBVM	-0.83	0.10	0.52	-0.24	0.45
SDVM	0.86	0.86	1.02	0.69	0.46
REVM	1.20	0.86	1.15	0.73	0.64
MINV UBAR	-0.91	-0.86	-0.41	0.96	1.21
DBMI	-1.09	-0.14	0.41	0.04	0.79
SDMI	0.67	0.67	0.79	0.54	0.36
REMI	1.28	0.68	0.89	0.54	0.87

4-item WK simulation, numbers used in trees

		-2	-1	0	+1	+2
1-PL	UBAR	-0.53	-0.50	-0.20	0.67	0.83
BIWT	DBAR	-1.47	-0.50	0.20	0.33	1.17
	S.D.	0.43	0.43	0.51	0.34	0.23
	RMSE	1.53	0.66	0.55	0.47	1.19
VARM	UBAR	-1.18	-1.11	-0.51	1.24	1.56
	DBVM	-0.82	0.11	0.51	-0.24	0.44
	SDVM	0.85	0.86	1.02	0.68	0.46
	REVM	1.19	0.87	1.14	0.72	0.64
MINV	UBAR	-0.92	-0.86	-0.40	0.96	1.22
	DBMI	-1.08	-0.14	0.40	0.04	0.78
	SDMI	0.67	0.67	0.80	0.53	0.36
	REMI	1.27	0.69	0.89	0.53	0.86
1-PL	UBAR	-0.78	-0.73	-0.29	1.04	1.30
AMJK	DBAR	-1.22	-0.27	0.29	-0.04	0.70
	S.D.	0.66	0.66	0.77	0.54	0.38
	RMSE	1.39	0.71	0.82	0.54	0.80
VARM	UBAR	-1.16	-1.10	-0.52	1.22	1.56
	DBVM	-0.84	0.10	0.52	-0.22	0.44
	SDVM	0.86	0.87	1.01	0.71	0.50
	REVM	1.20	0.87	1.13	0.75	0.67
MINV	UBAR	-0.90	-0.85	-0.40	0.95	1.21
	DBMI	-1.10	-0.15	0.40	0.05	0.79
	SDMI	0.67	0.67	0.78	0.55	0.39
	REMI	1.29	0.69	0.88	0.56	0.88
2-PL	UBAR	-0.60	-0.59	-0.21	0.80	0.97
MEAN	DBAR	-1.40	-0.41	0.21	0.20	1.03
	S.D.	0.48	0.47	0.60	0.33	0.19
	RMSE	1.48	0.62	0.64	0.39	1.05
VARM	UBAR	-1.17	-1.17	-0.50	1.28	1.56
	DBVM	-0.83	0.17	0.50	-0.28	0.44
	SDVM	0.84	0.82	1.05	0.58	0.34
	REVM	1.18	0.84	1.16	0.65	0.55
MINV	UBAR	-0.93	-0.92	-0.40	1.01	1.24
	DBMI	-1.07	-0.08	0.40	-0.01	0.76
	SDMI	0.67	0.65	0.83	0.46	0.27
	REMI	1.26	0.66	0.92	0.46	0.81
2-PL	UBAR	-0.48	-0.48	-0.18	0.64	0.76
M.25	DBAR	-1.52	-0.52	0.18	0.36	1.24
	S.D.	0.38	0.37	0.48	0.26	0.15
	RMSE	1.56	0.64	0.51	0.45	1.25
VARM	UBAR	-1.18	-1.17	-0.50	1.29	1.56
	DBVM	-0.82	0.17	0.50	-0.29	0.44
	SDVM	0.84	0.82	1.06	0.57	0.31
	REVM	1.17	0.84	1.17	0.64	0.55
MINV	UBAR	-0.93	-0.93	-0.39	1.02	1.24
	DBMI	-1.07	-0.07	0.39	-0.02	0.76
	SDMI	0.66	0.65	0.84	0.45	0.26
	REMI	1.26	0.65	0.93	0.45	0.81

Graphical Display - A-4

4-item WK simulation, numbers used in trees

	-2	-1	0	+1	+2
2-PL UBAR	-0.39	-0.38	-0.14	0.50	0.60
M.50 DBAR	-1.61	-0.62	0.14	0.50	1.40
S.D.	0.30	0.30	0.38	0.20	0.11
RMSE	1.64	0.68	0.41	0.54	1.40
VARM UBAR	-1.18	-1.17	-0.49	1.29	1.56
DBVM	-0.82	0.17	0.49	-0.29	0.44
SDVM	0.84	0.82	1.06	0.56	0.31
REVM	1.17	0.84	1.17	0.63	0.54
MINV UBAR	-0.94	-0.93	-0.39	1.02	1.23
DBMI	-1.06	-0.07	0.39	-0.02	0.77
SDMI	0.66	0.65	0.84	0.44	0.25
REMI	1.25	0.66	0.93	0.44	0.80
2-PL UBAR	-0.23	-0.23	-0.09	0.30	0.36
M1.0 DBAR	-1.77	-0.77	0.09	0.70	1.64
S.D.	0.18	0.18	0.23	0.12	0.07
RMSE	1.77	0.79	0.25	0.71	1.64
VARM UBAR	-1.18	-1.17	-0.49	1.29	1.55
DBVM	-0.82	0.17	0.49	-0.29	0.45
SDVM	0.84	0.83	1.06	0.55	0.30
REVM	1.18	0.84	1.17	0.62	0.54
MINV UBAR	-0.93	-0.93	-0.39	1.02	1.23
DBMI	-1.07	-0.07	0.39	-0.02	0.77
SDMI	0.67	0.65	0.84	0.44	0.24
REMI	1.26	0.66	0.93	0.44	0.81
2-PL UBAR	-0.56	-0.56	-0.21	0.74	0.89
MODE DBAR	-1.44	-0.44	0.21	0.26	1.11
S.D.	0.45	0.44	0.55	0.31	0.18
RMSE	1.51	0.62	0.59	0.41	1.12
VARM UBAR	-1.17	-1.16	-0.50	1.28	1.56
DBVM	-0.83	0.16	0.50	-0.28	0.44
SDVM	0.84	0.82	1.05	0.59	0.35
REVM	1.18	0.84	1.16	0.65	0.56
MINV UBAR	-0.93	-0.92	-0.40	1.01	1.24
DBMI	-1.07	-0.08	0.40	-0.01	0.76
SDMI	0.67	0.65	0.83	0.47	0.27
REMI	1.26	0.66	0.92	0.47	0.81
2-PL UBAR	-0.37	-0.37	-0.14	0.47	0.56
H0.5 DBAR	-1.63	-0.63	0.14	0.53	1.44
S.D.	0.29	0.28	0.36	0.19	0.11
RMSE	1.66	0.69	0.39	0.56	1.44
VARM UBAR	-1.18	-1.17	-0.50	1.29	1.56
DBVM	-0.82	0.17	0.50	-0.29	0.44
SDVM	0.84	0.82	1.06	0.56	0.32
REVM	1.17	0.84	1.17	0.63	0.54
MINV UBAR	-0.93	-0.93	-0.39	1.02	1.24
DBMI	-1.07	-0.07	0.39	-0.02	0.76
SDMI	0.66	0.65	0.84	0.45	0.25
REMI	1.26	0.65	0.93	0.45	0.80

4-item WK simulation, numbers used in trees

	-2	-1	0	+1	+2
2-PL UBAR	-0.23	-0.23	-0.09	0.29	0.34
H1.0 DBAR	-1.77	-0.77	0.09	0.71	1.56
S.D.	0.18	0.17	0.22	0.12	0.06
RMSE	1.78	0.79	0.24	0.72	1.66
VARM UBAR	-1.18	-1.17	-0.50	1.29	1.56
DBVM	-0.82	0.17	0.50	-0.29	0.44
SDVM	0.84	0.82	1.06	0.56	0.31
REVM	1.18	0.84	1.17	0.63	0.54
MINV UBAR	-0.93	-0.93	-0.39	1.02	1.23
DBMI	-1.07	-0.07	0.39	-0.02	0.77
SDMI	0.67	0.65	0.64	0.44	0.24
REMI	1.26	0.66	0.64	0.44	0.81
2-PL UBAR	-0.07	-0.07	-0.03	0.09	0.11
H2.0 DBAR	-1.93	-0.93	0.03	0.91	1.89
S.D.	0.06	0.05	0.07	0.04	0.02
RMSE	1.93	0.93	0.07	0.91	1.89
VARM UBAR	-1.17	-1.17	-0.51	1.28	1.56
DBVM	-0.83	0.17	0.51	-0.28	0.44
SDVM	0.85	0.82	1.06	0.56	0.31
REVM	1.19	0.83	1.18	0.62	0.54
MINV UBAR	-0.93	-0.93	-0.40	1.02	1.24
DBMI	-1.07	-0.07	0.40	-0.02	0.76
SDMI	0.67	0.65	0.84	0.44	0.24
REMI	1.27	0.65	0.93	0.44	0.80
2-PL UBAR	-0.53	-0.53	-0.20	0.68	0.82
BIWT DBAR	-1.47	-0.47	0.20	0.32	1.18
S.D.	0.41	0.40	0.52	0.28	0.16
RMSE	1.53	0.62	0.55	0.42	1.19
VARM UBAR	-1.18	-1.17	-0.50	1.28	1.56
DBVM	-0.82	0.17	0.50	-0.28	0.44
SDVM	0.84	0.82	1.05	0.57	0.33
REVM	1.17	0.83	1.16	0.64	0.55
MINV UBAR	-0.93	-0.93	-0.40	1.02	1.24
DBMI	-1.07	-0.07	0.40	-0.02	0.76
SDMI	0.66	0.65	0.84	0.45	0.26
REMI	1.25	0.65	0.92	0.45	0.80
3-PL UBAR	-0.61	-0.58	-0.24	0.88	1.10
MEAN DBAR	-1.39	-0.42	0.24	0.12	0.90
S.D.	0.42	0.39	0.52	0.43	0.22
RMSE	1.45	0.57	0.57	0.45	0.93
VARM UBAR	-1.21	-1.17	-0.59	1.30	1.66
DBVM	-0.79	0.17	0.59	-0.50	0.34
SDVM	0.70	0.66	0.88	0.73	0.37
REVM	1.06	0.68	1.06	0.79	0.50
MINV UBAR	-1.00	-0.96	-0.48	1.07	1.37
DBMI	-1.00	-0.04	0.48	-0.07	0.63
SDMI	0.58	0.54	0.72	0.60	0.30
REMI	1.16	0.54	0.87	0.60	0.70

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4-item WK simulation, numbers used in trees

		-2	-1	0	+1	+2
3-PL	UBAR	-0.49	-0.46	-0.18	0.67	0.84
M.25	DBAR	-1.51	-0.54	0.18	0.33	1.16
	S.D.	0.30	0.29	0.40	0.34	0.17
	RMSE	1.54	0.62	0.44	0.47	1.18
VARM	UBAR	-1.24	-1.16	-0.57	1.30	1.67
	DBVM	-0.76	0.16	0.57	-0.30	0.33
	SDVM	0.66	0.64	0.88	0.74	0.37
	REVM	1.01	0.66	1.04	0.80	0.50
MINV	UBAR	-1.03	-0.97	-0.47	1.08	1.38
	DBMI	-0.97	-0.03	0.47	-0.08	0.62
	SDMI	0.55	0.53	0.73	0.61	0.31
	REMI	1.12	0.53	0.87	0.62	0.69
3-PL	UBAR	-0.38	-0.35	-0.13	0.51	0.64
M.50	DBAR	-1.62	-0.65	0.13	0.49	1.36
	S.D.	0.23	0.22	0.31	0.27	0.14
	RMSE	1.63	0.69	0.34	0.56	1.36
VARM	UBAR	-1.25	-1.16	-0.55	1.29	1.67
	DBVM	-0.75	0.16	0.55	-0.29	0.33
	SDVM	0.65	0.63	0.88	0.76	0.41
	REVM	0.99	0.65	1.04	0.82	0.53
MINV	UBAR	-1.04	-0.96	-0.45	1.07	1.38
	DBMI	-0.96	-0.04	0.45	-0.07	0.62
	SDMI	0.53	0.53	0.73	0.63	0.34
	REMI	1.10	0.53	0.86	0.64	0.71
3-PL	UBAR	-0.22	-0.19	-0.06	0.26	0.33
M1.0	DBAR	-1.78	-0.81	0.06	0.74	1.57
	S.D.	0.12	0.13	0.18	0.15	0.10
	RMSE	1.79	0.82	0.19	0.76	1.67
VARM	UBAR	-1.27	-1.14	-0.46	1.24	1.63
	DBVM	-0.73	0.14	0.46	-0.24	0.37
	SDVM	0.65	0.67	0.94	0.81	0.53
	REVM	0.97	0.69	1.04	0.85	0.64
MINV	UBAR	-1.04	-0.93	-0.38	1.01	1.33
	DBMI	-0.96	-0.07	0.38	-0.01	0.67
	SDMI	0.53	0.55	0.76	0.67	0.43
	REMI	1.10	0.55	0.85	0.67	0.79
3-PL	UBAR	-0.34	-0.34	-0.03	0.88	1.01
MODE	DBAR	-1.66	-0.66	0.03	0.12	0.99
	S.D.	0.41	0.41	0.48	0.29	0.12
	RMSE	1.72	0.77	0.48	0.31	1.00
VARM	UBAR	-1.16	-1.17	-0.53	1.30	1.56
	DBVM	-0.84	0.17	0.53	-0.30	0.44
	SDVM	0.94	0.83	0.96	0.58	0.24
	REVM	1.26	0.84	1.10	0.65	0.50
MINV	UBAR	-0.92	-0.92	-0.42	1.02	1.23
	DBMI	-1.08	-0.08	0.42	-0.02	0.77
	SDMI	0.75	0.65	0.76	0.46	0.19
	REMI	1.32	0.66	0.87	0.46	0.79

4-item WK simulation, numbers used in trees

	-2	-1	0	+1	+2
3-PL UBAR	-0.24	-0.22	0.02	0.69	0.78
H0.5 DBAR	-1.76	-0.78	-0.02	0.31	1.22
S.D.	0.30	0.27	0.35	0.21	0.08
RMSE	1.79	0.83	0.35	0.37	1.22
VARM UBAR	-1.24	-1.17	-0.51	1.33	1.59
DBVM	-0.76	0.17	0.51	-0.33	0.41
SDVM	0.83	0.74	0.96	0.57	0.22
REVM	1.13	0.76	1.09	0.66	0.46
MINV UBAR	-1.01	-0.96	-0.42	1.09	1.30
DBMI	-0.99	-0.04	0.42	-0.09	0.70
SDMI	0.68	0.61	0.78	0.46	0.18
REMI	1.20	0.61	0.89	0.47	0.73
3-PL UBAR	-0.15	-0.13	0.04	0.49	0.56
H1.0 DBAR	-1.85	-0.88	-0.04	0.51	1.44
S.D.	0.16	0.16	0.24	0.16	0.07
RMSE	1.86	0.89	0.24	0.53	1.44
VARM UBAR	-1.29	-1.18	-0.50	1.34	1.63
DBVM	-0.71	0.18	0.50	-0.34	0.37
SDVM	0.67	0.66	0.96	0.63	0.26
REVM	0.98	0.68	1.08	0.72	0.46
MINV UBAR	-1.07	-0.98	-0.42	1.12	1.36
DBMI	-0.93	-0.02	0.42	-0.12	0.64
SDMI	0.56	0.55	0.80	0.53	0.22
REMI	1.08	0.55	0.90	0.54	0.68
3-PL UBAR	-0.05	-0.04	0.01	0.08	0.10
H2.0 DBAR	-1.95	-0.96	-0.01	0.92	1.90
S.D.	0.04	0.04	0.06	0.04	0.02
RMSE	1.95	0.96	0.06	0.92	1.90
VARM UBAR	-1.31	-1.14	-0.25	1.20	1.50
DBVM	-0.69	0.14	0.25	-0.20	0.50
SDVM	0.71	0.81	1.12	0.75	0.49
REVM	0.99	0.82	1.15	0.78	0.70
MINV UBAR	-1.05	-0.91	-0.20	0.96	1.20
DBMI	-0.95	-0.09	0.20	0.04	0.80
SDMI	0.56	0.64	0.89	0.60	0.39
REMI	1.11	0.65	0.92	0.60	0.90
3-PL UBAR	-0.48	-0.37	-0.02	0.81	0.94
BIWT DBAR	-1.52	-0.63	0.02	0.19	1.06
S.D.	0.36	0.36	0.46	0.30	0.10
RMSE	1.56	0.73	0.46	0.35	1.07
VARM UBAR	-1.36	-1.13	-0.41	1.32	1.58
DBVM	-0.64	0.13	0.41	-0.32	0.42
SDVM	0.74	0.75	0.96	0.62	0.20
REVM	0.98	0.76	1.04	0.69	0.46
MINV UBAR	-1.13	-0.94	-0.35	1.10	1.32
DBMI	-0.87	-0.06	0.35	-0.10	0.68
SDMI	0.62	0.63	0.80	0.51	0.17
REMI	1.07	0.63	0.87	0.52	0.70

Appendix B

The XTREE plotting programs are reproduced here. The crucial subroutine is XTREE:

Usage:

```
CALL XTREE(XO,YO,HT,WIDEL,WIDER,NODES,YLMAX,YRMAX,DATAR,DATAL,  
& ANGR,ANGL,IPEN)
```

Parameters:

XO,YO: (x,y) location of XTREE root, in inches

HT: height of XTREE, in inches

WIDEL,WIDER: widths of left and right sides of XTREE (inches)

NODES: number of (pairs of) branches

YLMAX,YRMAX: maximum left and right branch length

DATAR,DATAL: vectors of length NODES, giving the lengths of
right and left branches at each node

ANGR,ANGL: vector of length NODES, giving angles between the trunk
and the branches

IPEN: vector of length NODES, defining pen for each branch

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```

*#FRNH EXPLTREE =(FORM,NWARN)
C      PROGRAM TO MAKE MASTER EXPLANATORY TREES
      DIMENSION DR(12),DL(12),AR(12),AL(12),IPEN(12)
      DATA IPEN/1,2,2,2,2,2,2,2,2,2,2,2/
      DO 1 I=1,12
      DR(I)=1.-(I-1)*.05
      DL(I)=4.-(I-1)*.2
      AR(I)=1.
1      AL(I)=SQRT(.5/15.5)
      WRITE(6,2)
2      FORMAT('OPROGRAM TO MAKE EXPLANATORY TREES'/
& ' ENTER NUMBER OF BRANCHES')
      READ(5,3) N
3      FORMAT(I2)
      CALL PLOTS(1,5,6)
      CALL PLOTON
      CALL HAND
      CALL XTREE(6.,5.5,4.,4.,1.,N,4.,1.,DR,DL,AR,AL,IPEN)
      CALL PLOTOF
      CALL TYPER
      STOP
      END
      SUBROUTINE XTREE(X0,Y0,HT,WIDEL,WIDER,NODES,YLMAX,YRMAX,DATAR,
& DATAL,ANGR,ANGL,IPEN)
      DIMENSION DATAR(NODES),DATAL(NODES),ANGR(NODES),ANGL(NODES),
& IPEN(NODES)
C
C      PROGRAM FOR LITTLE TREE-LIKE GLYPHS
C
      PERIN=1020.
      IX0=X0*PERIN
      IY0=Y0*PERIN
      HTI=HT*PERIN
      SPACE=HTI/(NODES-1)
      WLI=WIDEL*PERIN
      WRI=WIDER*PERIN
C
      DO 20 I=1,NODES
C      SELECT PEN, LOCATE
      WRITE(6,2) IPEN(I),IX0,IY0
2      FORMAT(1X,'SP',I1,';PU',I5,',',I5,',;')
C      DO "TRUNK"
      IUP=IX0-SPACE*(I-1)
      WRITE(6,4) IUP,IY0
4      FORMAT(1X,'PD',I5,',',I5,',;')
C      DO RIGHT BRANCH
      ANGLE=ATAN(ANGR(I))
      IX=IUP-(DATAR(I)/YRMAX)*WRI*SIN(ANGLE)
      IY=IY0+(DATAR(I)/YRMAX)*WRI*COS(ANGLE)
      WRITE(6,6) IX,IY,IUP,IY0
6      FORMAT(1X,'PD',I5,',',I5,',;PA',I5,',',I5,',;PU')
C      DO LEFT BRANCH
      ANGLE=-ATAN(ANGL(I))
      IX=IUP-(DATAL(I)/YLMAX)*WLI*SIN(ANGLE)

```

```

      IY=IYO-(DATA1(I)/YLMAX)*WLI*COS(ANGLE)
      WRITE(6,6) IX,IY,IUP,IYO
C      FINISHED
20    CONTINUE
      RETURN
      END
      SUBROUTINE PLOT0F
      CHARACTER*1 ESC/'{esc}'/
      WRITE(6,1)
1      FORMAT(1X,'SP0;')
      WRITE(6,2) ESC
2      FORMAT(1X,A1,'.')')
      RETURN
      END
      SUBROUTINE PLOT0N
      CHARACTER*1 ESC/'{esc}'/
      WRITE(6,1) ESC
1      FORMAT(1X,A1,'.')')
      RETURN
      END
      SUBROUTINE HAND
      CHARACTER*1 ESC/'{esc}'/
C      SEND THIS AFTER PLOTTER ON---
      WRITE(6,1) ESC,ESC
1      FORMAT(1X,A1,'.I81;;17:',A1,'.N;19:')
C      SETS THRESHOLD FOR XOFF AT 81 BYTES LEFT-IN-BUFFER
C      XOFF IS CTL-S
C      XON IS CTL-Q
      RETURN
      END
      SUBROUTINE PLOTS(I1,I2,I
      CHARACTER*1 ESC/'{esc}'/,CTLT/'{ctl-t}'/
      WRITE(6,1) ESC
1      FORMAT(1X,A1,'.(:')
      WRITE(6,2) CTLT
2      FORMAT(1X,'IN;SP1;DIO,1;DT',A1,';')
      RETURN
      END
      SUBROUTINE TYPER
      CHARACTER*1 ESC/'{esc}'/,CTLT/'{ctl-t}'/
      DIMENSION A(16)
      DATA ASTOP/'STOP'/
C      THIS VERSION OF TYPER TAKES CTL-T AS END-OF-STRING
      WRITE(6,2091)
2091  FORMAT('OYOU ARE NOW IN TYPER...')
      WRITE(6,2092) ESC
2092  FORMAT(1X,A1,'.')')
      WRITE(6,2094)
2094  FORMAT(1X,'SP2;')
21    WRITE(6,22) ESC
22    FORMAT(1X,A1,'.')')
      READ(5,23) A
23    FORMAT(16A4)
      IF(A(1).EQ.ASTOP) GOTO 35

```

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```
      WRITE(6,146) ESC
146  FORMAT(1X,A1,'.(')
      WRITE(6,24) A
24   FORMAT(1X,'LB',16A4,'{ctl-t};CP; )
      GOTO 21
35   CONTINUE
      WRITE(6,3) LSC,ESC
3    FORMAT(1X,A1,'.(SPO;PAO,0;',A1,'.))
      RETURN
      END
```

```

*#FRNH TREE1=(NWARN,FORM)
C      PROGRAM TO GRAPH ROBUST SIMULATION RESULTS
C      T(I,J,K), I=1,28; J=1,9; K=1,5
C      CONTAINS, FOR
C      I=I, STATISTICS FOR ESTIMATOR I
C      J=J, 1,9 DIFFERENT CRITERIA
C      K=K, 1,5, U=-2,-1,0,+1,+2
C      PROGRAM READS T FROM FILE "01"
C      AND PLOTS IN STANDARD FORMAT ON REQUEST
C
      LOGICAL DEV
      DIMENSION T(28,9,5), IMODEL(28), IESTIM(28), JCRIT(9),
& U(5), IU(7), IY(3), Y(5), LU(16), ID(3)
      DIMENSION DR(4), DL(4), AR(4), AL(4), IPEN(4)
      DATA DR/1.,0.,0.,0./
      DATA DL/4.,0.,0.,0./
      DATA AR/1.,1.,1.,1./
      DATA IPEN/1,2,2,2/
C
      DATA IMODEL/'1-PL','1-PL','1-PL','1-PL','1-PL','1-PL','1-PL',
& '1-PL','1-PL','1-PL','2-PL','2-PL','2-PL','2-PL','2-PL',
& '2-PL','2-PL','2-PL','2-PL','3-PL','3-PL','3-PL','3-PL',
& '3-PL','3-PL','3-PL','3-PL'/
      DATA IESTIM/'MEAN','M.25','M.50','M1.0','MODE',
& 'H0.5','H1.0','H2.0','BIWT','AMJK',
& 'MEAN','M.25','M.50','M1.0','MODE',
& 'H0.5','H1.0','H2.0','BIWT',
& 'MEAN','M.25','M.50','M1.0','MODE',
& 'H0.5','H1.0','H2.0','BIWT'/
      DATA JCRIT/'DBAR','S.D.','RMSE','DBVM','SDVM','REVM',
& 'DBMI','SDMI','REMI'/
      DATA U/-2.,-1.,0.,1.,2./
      DATA NEW,ISTOP,D,V/'NEW','STOP','D','V'/
      DATA IU/' ','-2 ','-1 ',' 0 ',' +1 ',' +2 ',' '/
      DATA LU/'U'/
      DATA IY/' 0 ',' 1 ',' 2 '/
      DATA ID/' -2 ',' 0 ',' +2 '/
      DATA IPLUS/'+'/
      WRITE(6,2)
2      FORMAT(' PROGRAM TO PLOT ROBUST SIMULATION TREES, #1')
      DO 10 I=1,28
      DO 9 J=1,9
      READ(15,5) (T(I,J,K),K=1,5)
5      FORMAT(5F10.4)
9      CONTINUE
10     CONTINUE
C
C
100    WRITE(6,101)
101    FORMAT(' WHICH MODEL DO YOU WANT? (1,2,3)')
      READ(5,102) IPL
102    FORMAT(I1)
      IF(IPL.LT.1.OR.IPL.GT.3) STOP
      GOTO (210,220,230), IPL

```

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```

210  I1=1
      I2=10
      GOTO 300
220  I1=11
      I2=19
      GOTO 300
230  I1=20
      I2=28
C      WRITE TOP LINE
300  CALL PLOTS(1,5,6)
      CALL HAND
      X=0.5
      Y=0.5
      CALL LB(X,Y,1,IMODEL(I1))
      Y=1.4
      DO 310 I=1,5
      CALL LB(X,Y,1,IU(I+1))
310  Y=Y+1.25
C      DO 2 OR TEN LINES OF TREES
      DO 320 I=1,4
320  AL(I)=SQRT(.5/15.5)
      X=1.75
      DO 400 I=I1,I2
      Y=0.5
      X=X-0.25
      CALL LP(X,Y,1,ESTIM(I))
      X=X+0.25
      Y=1.925
      DO 380 K=1,5
      DL(2)=T(I,1,K)**2
      DL(3)=T(I,4,K)**2
      DL(4)=T(I,7,K)**2
      DR(2)=T(I,2,K)**2
      DR(3)=T(I,5,K)**2
      DR(4)=T(I,8,K)**2
      CALL XTREE(X,Y,0.75,0.8,0.2,4,4.,1.,DR,DL,AR,AL,IPEN)
      Y=Y+1.25
380  CONTINUE
      X=X+0.9
400  CONTINUE
      CALL PLOTOF
      CALL TYPEP
      GOTO 100
C
      END
      SUBROUTINE LB(X,Y,NWORD,A)
      CHARACTER*1 CTLT/'{ctl-t}'/
      DIMENSION A(NWORD)
      PERIN=1020.
      IX=X*PERIN
      IY=Y*PERIN
      WRITE(6,10) IX,IY,A,CTLT
10   FORMAT(1X,'PU',I5,',',I5,';LB',10A4,';')
      RETURN

```

```

END
SUBROUTINE XTREE(X0,Y0,HT,WIDEL,WIDER,NODES,YLMAX,YRMAX,DATAR,
& DATAL,ANGR,ANGL,IPEN)
  DIMENSION DATAR(NODES),DATAL(NODES),ANGR(NODES),ANGL(NODES),
& IPEN(NODES)
C
C      PROGRAM FOR LITTLE TREE-LIKE GLYPHS
C
  PERIN=1020.
  IX0=X0*PERIN
  IY0=Y0*PERIN
  HTI=HT*PERIN
  SPACE=HTI/(NODES-1)
  WLI=WIDEL*PERIN
  WRI=WIDER*PERIN
C
  DO 20 I=1,NODES
C      SELECT PEN, LOCATE
  WRITE(6,2) IPEN(I),IX0,IY0
  2  FORMAT(1X,'SP',I1,';PU',I5,',',I5,';')
C      DO "TRUNK"
  IUP=IX0-SPACE*(I-1)
  WRITE(6,4) IUP,IY0
  4  FORMAT(1X,'PD',I5,',',I5,';')
C      DO RIGHT BRANCH
  ANGLE=ATAN(ANGR(I))
  IX=IUP-(DATAR(I)/YRMAX)*WRI*SIN(ANGLE)
  IY=IY0+(DATAR(I)/YRMAX)*WRI*COS(ANGLE)
  WRITE(6,6) IX,IY,IUP,IY0
  6  FORMAT(1X,'D',I5,',',I5,' PA',I5,',',I5,';PV')
C      DO LEFT BRANCH
  ANGLE=ATAN(ANGL(I))
  IX=IUP-(DATAL(I)/YLMAX)*WLI*SIN(ANGLE)
  IY=IY0-(DATAL(I)/YIMAX)*WLI*COS(ANGLE)
  WRITE(6,6) IX,IY,IUP,IY0
C      FINISHED
  20 CONTINUE
  RETURN
END
SUBROUTINE PLOTF
  CHARACTER*1 ESC/'{esc}'/
  WRITE(6,1)
  1  FORMAT(1X,'SP0;')
  WRITE(6,2) ESC
  2  FORMAT(1X,A1,'.')
  RETURN
END
SUBROUTINE PLOTON
  CHARACTER*1 ESC/'{esc}'/
  WRITE(6,1) ESC
  1  FORMAT(1X,A1,'.(')
  RETURN
END
ROUTINE HAND

```

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```

CHARACTER*1 ESC/'{esc}'/
C   SEND THIS AFTER PLOTTER ON---
WRITE(6,1) ESC,ESC
1   FORMAT(1X,A1,'.I81;;17:',A1,'.N;19:')
C   SETS THRESHOLD FOR XOFF AT 81 B.YES LEFT-IN-BUFFER
C   XOFF IS CTL-S
C   XON IS CTL-Q
RETURN
END
SUBROUTINE PLOTS(I1,I2,I3)
CHARACTER*1 ESC/'{esc}'/,CTLT/'{ctl-t}'/
WRITE(6,1) ESC
1   FORMAT(1X,A1,'.(:')
WRITE(6,2) CTLT
2   FORMAT(1X,'IN;SP2;DIO,1;DT',A1,',';)
RETURN
END
SUBROUTINE TYPER
CHARACTER*1 ESC/'{esc}'/,CTLT/'{ctl-t}'/
DIMENSION A(16)
DATA ASTOP/'STOP'/
C   THIS VERSION OF TYPER TAKES CTL-T AS END-OF-STRING
WRITE(6,2091)
2091 FORMAT('OYOU ARE NOW IN TYPER...')
WRITE(6,2092) ESC
2092 FORMAT(1X,A1,'.(')
WRITE(6,2094)
2094 FORMAT(1X,'SP2;')
21  WRITE(6,22) ESC
22  FORMAT(1X,A1,'.(')
READ(5,23) A
23  FORMAT(16A4)
IF(A(1).EQ.ASTOP) GOTO 35
WRITE(6,146) ESC
146 FORMAT(1X,A1,'.(')
WRITE(6,24) A
24  FORMAT(1X,'LB',16A4,'{cli-t};CP;')
GOTO 21
35  CONTINUE
WRITE(6,3) ESC,ESC
3   FORMAT(1X,A1,'.(SP0;PA0,0;',A1,'.(')
RETURN
END

```

```

*#FRNH TREE3=(NWARN,FORM)
C      PROGRAM TO GRAPH ROBUST SIMULATION RESULTS
C      T(I,J,K), I=1,28; J=1,9; K=1,5
C      CONTAINS, FOR
C      I=I, STATISTICS FOR ESTIMATOR I
C      J=J, 1,9 DIFFERENT CRITERIA
C      K=K, 1,5, U=-2,-1,0,+1,+2
C      PROGRAM READS T FROM FILE "01"
C      AND PLOTS IN STANDARD FORMAT ON REQUEST
C
      LOGICAL DEV
      DIMENSION T(28,9,5), IMODEL(28), IESTIM(28), JCRIT(9),
& U(5), IU(7), IY(3), Y(5), LU(16), ID(3)
      DIMENSION DR(11), DL(11), AR(11), AL(11), IPEN(11)
      DATA AR/1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1./
      DATA IPEN/1,2,2,2,2,2,2,2,2,2,2/
C
      DATA IMODEL/'1-PL','1-PL','1-PL','1-PL','1-PL','1-PL','1-PL',
& '1-PL','1-PL','1-PL','2-PL','2-PL','2-PL','2-PL','2-PL',
& '2-PL','2-PL','2-PL','2-PL','3-PL','3-PL','3-PL','3-PL',
& '3-PL','3-PL','3-PL','3-PL'/
      DATA IESTIM/'MEAN','M.25','M.50','M1.0','MODE',
& 'H0.5','H1.0','H2.0','BIWT','AMJK',
& 'MEAN','M.25','M.50','M1.0','MODE',
& 'H0.5','H1.0','H2.0','BIWT',
& 'MEAN','M.25','M.50','M1.0','MODE',
& 'H0.5','H1.0','H2.0','BIWT'/
      DATA JCRIT/'DBAR','S.D.','RMSE','DBVM','SDVM','REVM',
& 'DBMI','SDMI','REMI'/
      DATA U/-2.,-1.,0.,1.,2./
      DATA NEW,ISTOP,D,V/'NEW','STOP','D','V'/
      DATA IU/' ','-2 ','-1 ',' 0 ',' +1 ',' +2 ',' '/
      DATA LU/'U'/
      DATA IY/' 0 ',' 1 ',' -2'/
      DATA ID/' -2 ',' 0 ',' +2'/
      DATA IPLUS/'+'/
      WRITE(6,2)
2      FORMAT(' PROGRAM TO PLOT ROBUST SIMULATION TREES, #3')
      DO 10 I=1,28
      DO 9 J=1,9
      READ(15,5) (T(I,J,K),K=1,5)
5      FORMAT(5F10.4)
9      CONTINUE
10     CONTINUE
C
C
100    WRITE(6,101)
101    FORMAT(' WHICH SCALING DO YOU WANT? (1=AS IS, '/
& ' 2=VARIANCE MATCHED, 3=MINIMUM RMSE)')
      READ(5,102) IRS
102    FORMAT(I1)
      IF(IRS.LT.1.OR.IRS.GT.3) STOP
      WRITE(6,103)
103    FORMAT(' ENTER LEFT AND RIGHT BASE LENGTHS')

```

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```

        READ,DL(1),DR(1)
        GOTO (210,220,230), IRS
210    I1=1
        GOTO 300
220    I1=4
        GOTO 300
230    I1=7
C      WRITE TOP LINE
300    CALL PLOTS(1,5,6)
        CALL HAND
        X=0.5
        Y=0.5
        CALL LB(X,Y,1,JCRIT(I1+2))
        Y=1.4
        DO 10 I=1,5
        CALL LB(X,Y,1,IU(I+1))
310    Y=Y+1.25
C      DO THREE LINES OF TREES
        TOTAL=DL(1)+DR(1)
        RL=DL(1)/TOTAL
        RR=DR(1)/TOTAL
        DO 320 I=1,11
320    AL(L)=SQRT((0.5*DR(1)**2)/(IL(1)**2-0.5*DR(1)**2))
        X=3.0
        I2=1
        I9=11
        IADD=-1
        DO 400 L=1,3
        Y=0.5
        X=X-0.5
        CALL LB(X,Y,1,IMODEL(I2))
        X=X+0.5
        Y=1.925
        DO 380 K=1,5
        DO 340 I=2,I9
        DL(I)=T(I+IADD,I1,K)**2
340    DR(I)=T(I+IADD,I1+1,K)**2
        CALL XTREE(X,Y,2.0,RL,RR,I9,DL(1),DR(1),DR,DL,AR,AL,IPEN)
        Y=Y+1.25
380    CONTINUE
        X=X+2.5
        IF(L.NE.1) GOTO 395
        I2=11
        I9=10
        IADD=9
        GOTO 400
395    I2=I2+9
        IADD=IADD+9
400    CONTINUE
        CALL PLOT0F
        CALL TYPER
        GOTO 100
C      END

```

```

SUBROUTINE LB(X,Y,NWORD,A)
CHARACTER*1 CTLT/'{ctl-t} '/
DIMENSION A(NWORD)
PERIN=1020.
IX=X*PERIN
IY=Y*PERIN
WRITE(6,10) IX,IY,A,CTLT
10 FORMAT(1X,'PU',I5,',',',I5,',';LB',10A4,',')
RETURN
END
SUBROUTINE XTREE(X0,Y0,HT,WIDEL,WIDER,NODES,YLMAX,YRMAX,DATAR,
& DATAL,ANGR,ANGL,IPEN)
DIMENSION DATAR(NODES),DATAL(NODES),ANGR(NODES),ANGL(NODES),
& IPEN(NODES)
C
C      PROGRAM FOR LITTLE TREE-LIKE GLYPHS
C
PERIN=1020.
IX0=X0*PERIN
IY0=Y0*PERIN
HTI=HT*PERIN
SPACE=HTI/(NODES-1)
WLI=WIDEL*PERIN
WRI=WIDER*PERIN
C
DO 20 I=1,NODES
C      SELECT PEN, LOCATE
WRITE(6,2) IPEN(I),IX0,IY0
2  FORMAT(1X,'SP',I1,',',',PU',I5,',',',I5,',';)
C      DO "TRUNK"
IUP=IX0-SPACE*(I-1)
WRITE(6,4) IUP,IY0
4  FORMAT(1X,'PD',I5,',',',I5,',';)
C      DO RIGHT BRANCH
ANGLE=ATAN(ANGR(I))
IX=IUP-(DATAR(I)/YRMAX)*WRI*SIN(ANGLE)
IY=IY0+(DATAR(I)/YRMAX)*WRI*COS(ANGLE)
WRITE(6,6) IX,IY,IUP,IY0
6  FORMAT(1X,'PD',I5,',',',I5,',';PA',I5,',',',I5,',';PU')
C      DO LEFT BRANCH
ANGLE=ATAN(ANGL(I))
IX=IUP-(DATAL(I)/YLMAX)*WLI*SIN(ANGLE)
IY=IY0-(DATAL(I)/YLMAX)*WLI*COS(ANGLE)
WRITE(6,6) IX,IY,IUP,IY0
C      FINISHED
20 CONTINUE
RETURN
END
SUBROUTINE PLOTF
CHARACTER*1 ESC/'{esc}' /
WRITE(6,1)
1  FORMAT(1X,'SP0;')
WRITE(6,2) ESC
2  FORMAT(1X,A1,'.')

```

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```

        RETURN
        END
        SUBROUTINE PLOTON
        CHARACTER*1 ESC/'{esc}'/
        WRITE(6,1) ESC
1      FORMAT(1X,A1,'.(')
        RETURN
        END
        SUBROUTINE HAND
        CHARACTER*1 ESC/'{esc}'/
C      SEND THIS AFTER PLOTTER ON---
        WRITE(6,1) ESC,ESC
1      FORMAT(1X,A1,'.I81;;;17:',A1,'.N;19:')
C      SETS THRESHOLD FOR XOFF AT 81 BYTES LEFT-IN-BUFFER
C      XOFF IS CTL-S
C      XON IS CTL-Q
        RETURN
        END
        SUBROUTINE PLOTS(I1,I2,I3)
        CHARACTER*1 ESC/'{esc}'/,CTLT/'{ctl-t}'/
        WRITE(6,1) ESC
1      FORMAT(1X,A1,'.(:')
        WRITE(6,2) CTLT
2      FORMAT(1X,'IN;SP2;DIO,1;DT',A1,';')
        RETURN
        END
        SUBROUTINE TYPER
        CHARACTER*1 ESC/'{esc}'/,CTLT/'{ctl-t}'/
        DIMENSION A(16)
        DATA ASTOP/'STOP'/
C      THIS VERSION OF TYPER TAKES CTL-T AS END-OF-STRING
        WRITE(6,2091)
2091  FORMAT('YOU ARE NOW IN TYPER...')
        WRITE(6,2092) ESC
2092  FORMAT(1X,A1,'.(')
        WRITE(6,2094)
2094  FORMAT(1X,'SP2;')
21    WRITE(6,22) ESC
22    FORMAT(1X,A1,'.))')
        READ(5,23) A
23    FORMAT(16A4)
        IF(A(1).EQ.ASTOP) GOTO 35
        WRITE(6,146) ESC
146   FORMAT(1X,A1,'.(')
        WRITE(6,24) A
24    FORMAT(1X,'LB',16A4,'{ctl-t};CP;')
        GOTO 21
35    CONTINUE
        WRITE(6,3) ESC,ESC
3      FORMAT(1X,A1,'.(SP0;PA0,0;',A1,'.))')
        RETURN
        END

```